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Abstract
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Keywords
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Is the effectiveness of lecture capture related to teaching approach or content type?

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ABSTRACT

The purpose of two related studies was to explore the relationships between course characteristics (teaching approach, content type, and level of curricular coordination), lecture-capture implementation, and learning in a veterinary medical education environment. Two hundred and twenty two students and 35 faculty members participated in the first study, which surveyed respondents regarding their perception of lecture-capture use and impact on learning. Four hundred and ninety one students participated in the second study, which compared scores on a standardized test of basic science knowledge among groups experiencing various levels of lecture-capture implementation. Students were most likely to view captured lectures in courses that moved quickly, relied heavily on lecture, were perceived as highly relevant to their future success, and contained information not available in other formats. A greater percentage of students than faculty perceived lecture capture as beneficial to learning. Higher views of captured lectures were associated with higher test scores in disciplines that relied most heavily on a *straight-lecture* teaching approach and had a *basic science – research* teaching context. The number of lecture-capture views was not significantly related to test scores in disciplines that relied less heavily on straight lecture for instruction and had a *basic science – applied* teaching context.

1. Introduction

For nearly as long as film and video have existed, they have been used for teaching. However, only in the past decade has it become routine to capture audio and video from traditional classroom lectures and automatically make those recordings available to enrolled students. These captured lectures vary in nature from relatively sophisticated video and audio productions to simple audio recordings that accompany a separate file containing presentation slides. The wide variations in lecture-capture technologies and implementation strategies have precipitated diverse studies examining lecture capture, with a variety of results. We reviewed only English-language studies, and focused on studies in post-secondary settings that used captured lectures as an adjunct to face-to-face instruction, so as to be comparable to the setting in which the present studies occurred. The cited studies were all conducted in the United States, Great Britain, Canada or Australia, and occurred in a variety of disciplines including medicine, physics, business, engineering and genetics. We could not identify any systematic meta-analyses providing a consensus regarding the relationship between lecture-capture use and learning outcomes in a post-secondary or any other learning context. In general terms, we identified a mixture of outcomes, with some studies reporting no clear relationship between lecture-capture use and learning (Bacro, Gebregziabher, & Fitzharris, 2010; Brotherton & Abowd, 2004; Franklin, Gibson, Samuel, Teeter, & Clarkson, 2011; Solomon, Ferenchick, Laird-Fick, & Kavanaugh, 2004; Spickard, Alrajeh, Cordray, & Gigante, 2002), some reporting a mixed or negative relationship (Fernandes, Moira, & Cruickshank, 2012; Franklin et al., 2011; McNulty et al., 2009, 2011; Owston, Lupshenyuk, & Wideman, 2011), and some reporting a positive relationship (Bridge, Jackson, & Robinson, 2009; Dey, Burn, & Gerdes, 2009; Elsasser, Hoie, Destache, & Monaghan, 2009; Shaw & Molnar, 2011; von Konsky, Ivins, & Gribble,

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2009). Regardless of findings from objective learning outcomes measures, students themselves tend to believe overwhelmingly that having access to captured lectures helps learning (Bacro et al., 2010; Brotherton & Abowd, 2004; Cardall, Krupat, & Ulrich, 2008; Dey et al., 2009; Franklin et al., 2011; Heilesen, 2010; Holbrook & Dupont, 2011; Lovell & Plantegenest, 2009; Mattick, Crockr, & Bligh, 2007; Pilarski, Johnstone, Pettepher, & Osheroff, 2008; Scutter, Stupans, Sawyer, & King, 2010; Solomon et al., 2004; Spickard et al., 2002; von Konsky et al., 2009; Yudko, Hirokawa, & Chi, 2008). Neither learning outcomes nor student perception seemed to vary systematically by discipline or by the country in which the study was conducted, though a systematic exploration of those factors was beyond the scope of the present study.

1.1. Related research

Among the potential mechanisms by which lecture capture influences learning, some studies suggest that flexibility and efficiency play a role. In one case, students reported studying less in a lecture capture enabled class, while maintaining equivalent grades (Brotherton & Abowd, 2004). In another study, medical students reported that captured lectures helped them learn for reasons such as being able to select learning methods that worked for them, being able to watch lectures at any time of day, thereby improving productivity and sleep, and being able to watch lectures at their own pace. The same students reported increasing how much they could study in a given time frame by changing lecture playback speed or by selectively watching only lecture segments they missed (Cardall et al., 2008). Using such strategies, students in an online lecture group were shown to learn just as much as students in a face-to-face lecture group in significantly less time (Spickard et al., 2002). For non-native language learners, captured lectures produced learning gains, presumably because they allow students to slow down or repeat difficult, unfamiliar, or fast-moving content that would otherwise have been lost (Scutter et al., 2010; Shaw & Molnar, 2011; Simpson, 2006). In the words of one author, “the medium of video capture was found to create an impression of intimacy simultaneously cleansed of environmental distractions, an experience not necessarily consistent with live attendance.” (Simpson, 2006, p. 527). Students cite other advantages of lecture capture, including the ability to review key points, obtain additional clarity, make up for unavoidable conflicts, and review for tests (Simpson, 2006; Wilson & Weiser, 2001; Winer & Cooperstock, 2002; Yudko et al., 2008).

1.2. Aims of the present studies

While existing studies form a useful foundation, much is still unknown about the use and impact of lecture capture. For instance, it is unclear what relationships exist between specific course characteristics such as teaching approach or content area and the perceived or actual value of the captured lectures. This paper describes two related studies that seek to address this deficiency by answering the following research questions:

1. What is the relationship between instructor teaching approach and the attitudes that instructors and students have toward lecture capture? (First study)
2. What is the relationship between curricular coordination and the attitudes that instructors and students have toward lecture capture? (First study)
3. What is the relationship between course content type and the attitudes that instructors and students have toward lecture capture? (First study)
4. What is the relationship between use of lecture capture and learning? (Second study)

We identified teaching approach, curricular coordination, and content type as factors that might affect how students perceive and use lecture capture using a process described in Section 2.1.2.

1.3. Context

The studies described herein occurred at a college of veterinary medicine located in the Midwest region of the United States. Beginning in 2007 the college introduced lecture-capture technology using the Echo360 system. Each captured lecture combined three sources of data. First, a fixed video camera mounted in the ceiling in each of the school’s three main lecture halls recorded the area behind the podium generally occupied by the instructor. Second, a wireless microphone captured the instructor’s voice for the Echo360 recording and for the classroom sound system. Finally, a computerized workstation captured all information that the instructor demonstrated to students via the data projector, including slide presentations, videos demonstrated in class, and so forth. Students accessed captured lectures by clicking links available within the course webpage. Captured lectures were displayed in a resizable internet browser window with a navigation panel and included one frame showing video of the instructor and another showing the content projected by the instructor while lecturing. Additionally, instructors could opt to make downloadable podcast (audio only) and vodcast (audio and video) recordings of the captured lectures available to students for off-line use.

Initially the college implemented Echo360 such that all lectures were captured for all core courses, but these captures were made available to students only if the instructors specifically chose to opt in to the program. After approximately one year of implementation, this opt-in policy was changed to an opt-out policy, in which all lectures were made available to students unless faculty specifically requested that they not be made available. Implementation gradually increased from semester to semester as faculty became more comfortable with the idea of students using captured lectures and as students increasingly requested access to captured lectures. Even after making the regular Echo360 streams available to students within the password-protected course webpage, many instructors did not release podcasts or vodcasts because of intellectual property concerns. There was no institution-wide teaching approach or attendance policy, though attendance was generally not a requirement in lecture sessions.

2. First study – student and faculty perceptions of lecture capture by course characteristics

The first study used a mixed-methods (focus group and survey) approach. Our survey instruments generated both Likert scale and open-ended response data to address the research questions.

2.1. Method

2.1.1. Participants

All enrolled veterinary students ($N = 565$) and all faculty members teaching in classroom-based courses ($N = 73$) during 2010 were invited to participate in the study. To reduce the likelihood of response bias, both student and faculty responses were collected anonymously. At the time of the study, the enrolled veterinary students were 73% female and 26% male; 48.5% were between the ages of 21 and 25, 43.3% were between the ages of 26 and 30, and 8.2% were older than 30. The students were predominantly white (85.2%), with 2% being Hispanic, 0.7% Asian, and 0.2% East Indian. Sixty six students (11.8%) did not report any information regarding their race. Study participants were those students ($n = 222$, 39% response rate) and faculty ($n = 35$, 48% response rate) who responded to their respective surveys. Faculty members responded about each course they taught, and in some cases, multiple faculty members responded about the same course. Faculty respondents taught courses in all four years of the curriculum, with nearly equivalent numbers of faculty teaching in each of the four years of the curriculum (16 in years 1 and 2, 14 in year 3 and 15 in year 4). Similarly, faculty respondents taught in similar numbers in basic and clinical science courses, with 15 teaching in the clinical sciences, 11 teaching in the basic sciences, 8 teaching in a variety of courses (basic science, clinical science, and non-traditional), and one reporting teaching only in an ethics course (categorized as non-traditional). Thirty one (89%) of faculty respondents reported making captured lectures available in their courses. All told, faculty responses represented 30 veterinary courses, and one graduate course. The graduate course could have included both veterinary students and graduate students. Student participants included first-year (23%), second-year (25%), third-year (38%), and fourth-year (15%) veterinary students. These proportions slightly under-represented the fourth-year student population and slightly over-represented the third-year student population. The lower proportion of 4th year respondents was expected because fourth-year students were participating in clinical rotations, causing some to be unavailable to respond. At the time that students responded, lecture captures were being collected and made available to students for 33 core courses and 12 elective courses. Therefore, student responses reflected 45 courses total. Most student participants (98%) reported having reviewed captured lectures.

2.1.2. Definitions

We determined that teaching approach, curricular coordination, and content type, were relevant factors to consider in the context of this study after exploring a survey that is routinely administered to all graduating seniors at the participating institution. We used factor analysis to analyze student responses to questions regarding core courses, and identified five clear course groupings. We initially characterized those five course groupings by asking a veterinary student who had taken all the courses in question to indicate similarities and differences among the courses in each group. Finally, we sought input regarding these course categorizations from 23 veterinary students during five focus group sessions containing 2–9 students each. While the initial factor analysis produced 5 course groupings, discussion with the students revealed that those groupings represented 3 primary factors, each having several levels, as described below:

The first factor, **teaching approach**, was characterized by three distinct approaches, or levels:

1. *Straight lecture* featured almost exclusively formal in-class presentations by the instructor(s).
2. *Interactive lecture* featured occasional interaction, such as answering clicker questions, in a predominantly lecture-based context.
3. *Mixed lecture and group work* involved instructor lecture accompanied by group work, including courses taught using Team Based Learning (TBL) as defined by Michaelsen, Knight, and Fink (2004).

The second factor, **curricular coordination**, was characterized by two levels:

1. *Tight curricular coordination* involved careful planning and coordination by a small number of instructors with clear goals.
2. *Loose curricular coordination* involved less coordination among a relatively large number of instructors.

The third factor, **course content type**, was characterized by four levels:

1. *Clinical or problem solving* courses were inherently clinical or involved problem solving subject matter, such as medicine or surgery.
2. *Basic science – applied* courses taught basic science material in an applied, case-based context.
3. *Basic science – research* courses taught basic science material in a non-applied, research or memorization-based context.
4. *Non-traditional* courses were seen by students as less central to diagnosing and treating patients in the future, such as veterinary societal issues, ethics, and communication.

Additionally, focus group participants suggested several other factors potentially influencing students' decisions to view or not to view captured lectures. We included those factors, described below, in the students' lecture-capture survey instrument:

1. *Lecture delivery speed*. Some focus group participants believed that they were more likely to view captured lectures when the instructor moved through the material very quickly.
2. *Amount of information included in handouts*. Some students believed that they were more likely to review lectures when important details that were covered in the lectures were excluded from the handouts.
3. *Availability of visual aids in the captured lecture*. When all of the instructor's relevant annotations were captured in the Echo360 recording, participants felt they were more likely to review the recording than when they were not. For instance, students may have

been more likely to review recordings when the instructor used digital ink annotations, which are captured, than when the instructor used the laser pointer, which was not captured.

4. *Perceived relevance of the information being presented*. Focus group participants said they were most likely to review information they perceived as likely to appear on a test and/or directly relevant to their ultimate goal of practicing as veterinarians.
5. *Whether or not instructors read from their slides*. Some students felt they would be less likely to view lectures in which instructors mostly read from their slides.

Table 1
Median likelihood of viewing lectures by course and/or instructor characteristic, or frequency of reviewing captured lectures for the stated purpose.

Course and/or instructor characteristic	*N*	Median (25th percentile–75th percentile)
Teaching approach		
Straight lecture	191	5 (4–5)[a]
Interactive lecture	191	4 (2–4)[a]
Mixed lecture/group work	191	2 (1–3)[a]
Mostly group discussion	191	1 (1–2)[a]
Level of curricular coordination		
Tight curricular coordination	187	4 (3–4)[a]
Loose curricular coordination	188	4 (3–5)[a]
Content type		
Clinical problem solving course	184	4 (3–5)[a]
Basic science – applied	191	4 (3–5)[a]
Basic science – research orientation	190	4 (3–5)[a]
Non-traditional courses	191	2 (1–3)[a]
Purpose for reviewing captured lectures (most to least common)		
To review segments of lectures flagged in notes.	201	4 (4–5)[b]
To review a lecture that went so fast you couldn't keep up.	201	4 (4–5)[b]
To study for exams.	199	4 (3–5)[b]
To review material that you missed because of extenuating circumstances (e.g. illness, poor road conditions, etc.).	199	4 (3–5)[b]
To review material you missed because you chose not to attend class without extenuating circumstances.	169	2 (1–3)[b]
To verify whether or not information provided by one course or instructor is consistent with information provided by another course or instructor.	184	1 (1–3)[b]
To review how concepts taught at the end of one class period relate to concepts taught at the beginning of the next class period.	192	1 (2–3)[b]
Instructor characteristics/behaviors (ordered from most to least likely to accompany increased viewing of captured lectures)		
The instructor moves through the material very quickly.	194	5 (5–5)[a]
I am not provided with course notes or PowerPoint slides ahead of time.	192	5 (4–5)[a]
The slide presentation does not match available handouts.	194	5 (4–5)[a]
The instructor routinely adds information beyond what is contained in the PowerPoint slides, and I consider the added information to be relevant because it contributes to my understanding of course material.	191	5 (4–5)[a]
The instructor routinely adds information beyond what is contained in the PowerPoint slides, and I consider the added information to be relevant because it might be on the test.	191	5 (4–5)[a]
All the visual aids and multimedia tools the instructor used were captured by the Echo system (i.e., the instructor used digital ink or the cursor to point out and discuss images.).	193	5 (4–5)[a]
I generally consider the instructor to be a good lecturer and the material to be relevant.	188	4 (4–5)[a]
I generally consider the instructor to be a poor lecturer and the material to be relevant.	190	4 (4–5)[a]
I feel the lecturer is generally well organized.	189	4 (3–5)[a]
I feel the lecturer is generally poorly organized.	191	4 (3–5)[a]
I generally consider the instructor to be a good lecturer.	191	4 (3–4)[a]
I generally consider the instructor to be a poor lecturer.	190	3 (2–5)[a]
Not all visual aids and multimedia tools the instructor used were captured in the Echo capture (i.e. the instructor uses a laser pointer to point to relevant images.).	190	3 (2–4)[a]
No additional insight is provided beyond what is available in the textbook or other published course materials.	192	3 (2–4)[a]
The instructor mostly reads the PowerPoint slides.	193	2 (1–4)[a]
I generally consider the instructor to be a good lecturer and the material to be irrelevant.	189	2 (1–3)[a]
I generally consider the instructor to be a poor lecturer and the material to be irrelevant.	188	2 (1–2)[a]
The instructor routinely adds information beyond what is contained in the PowerPoint slides, and I consider the added information to be irrelevant.	185	1 (1–2)[a]

[a] Scale: 1 = very unlikely, 2 = somewhat unlikely, 3 = no effect on likelihood, 4 = somewhat likely, and 5 = very likely.
[b] Scale: 1 = almost never, 2 = infrequently, 3 = neither frequently nor infrequently, 4 = frequently, 5 = almost always.

6. *Instructor's skill as a lecturer*. Some focus group participants hypothesized that students would be more likely to view lectures presented by highly skilled speakers.
7. *Lecture organization*. Researchers and focus group participants wondered if students might be more likely to review lectures that were not well organized in an attempt to impose structure on the content.
8. *Other uses*. Some focus group participants suggested several other strategies for lecture-capture use that were also included in the survey, such as making comments to themselves to strategically review certain captured lectures later, providing continuity by watching lectures that originally occurred days apart one after the other, and verifying consistency between what instructors said in different courses or lectures. All potential uses of lecture capture that were included in the survey can be found in Table 1.

2.1.3. Instruments

We designed two surveys, one for students and one for faculty. Students were asked to indicate the extent to which they felt that teaching approach, curricular coordination, and content type influenced how much they valued and used captured lectures. In addition to those factors, we also asked students about the additional factors identified during focus group interviews (discussed above). Faculty were asked to indicate their teaching approach, the type of content included in the course being reported on, and their attitudes toward lecture capture. Both surveys allowed respondents to make open-ended comments.

2.1.4. Procedure

The study was approved by the Institutional Review Board at the university where the research was conducted. Approximately three years following initial implementation of the Echo360 system, during April and May of 2010, we invited students to respond to an online survey regarding their attitudes toward the lecture-capture program. Slightly later (between October and December in 2010), we invited instructors to share their perceptions of lecture capture using an online survey.

We analyzed differences among Likert responses using non parametric tests with SPSS v. 19. We used an open-coding process to analyze responses to open-ended data in which one rater reviewed all comments and generated thematic categories, and a second rater reviewed and verified the categories.

2.2. Results

2.2.1. Teaching approach and student use of captured lectures

Students indicated how likely they would be to view captured lectures for class session with various interactivity levels: (a) "Straight lecture (mostly formal in-class presentations by the instructor, with very little class participation)", (b) "Interactive lecture (straight lecture with some interaction between the instructor and students, such as clicker questions)", (c) "Mixed lecture/group work (the instructor's lecture is accompanied by group work, such as Team Based Learning (TBL))", and (d) "Sessions with mostly group discussion." They responded using a 5 point scale: 1 = Very unlikely, 2 = Somewhat Unlikely, 3 = No effect on likelihood, 4 = Somewhat likely, and 5 = Very likely. The median likelihood of viewing a captured lecture by teaching approach is reported in Table 1. A Friedman test revealed that the likelihood that students would view captured lectures varied significantly depending on the level of lecture interactivity in the teaching approach ($\chi^2(3) = 429.567$, $p < .0005$). As seen in Table 1, there was an inverse relationship between the interactivity of a class session and the likelihood that the students would report viewing a captured lecture of that session. Post-Hoc Wilcoxon tests revealed that students reported being significantly more likely to view recorded lectures in a straight-lecture course than in an interactive lecture course ($Z = -9.733$, $p < .0005$), more likely to view recorded lectures in an interactive lecture course than in a mixed lecture/group instruction course ($Z = -9.510$, $p < .0005$), and more likely to view recorded lectures in a mixed lecture/group instruction course than in a completely group instruction course ($Z = -8.1113$, $p < .0005$).

2.2.2. Curricular coordination and student use of captured lectures

Students indicated how likely they would be to view captured lectures "in courses characterized by tight curricular coordination (Characterized by careful planning and coordination among class sessions, with meaningful transitions and connections among topics.)" and "in courses characterized by loose curricular coordination (Characterized by the appearance that lectures have not been coordinated together, or multiple instructors may appear to be unaware of what each other are teaching in the class.)." They responded using a 5 point scale: 1 = Very unlikely, 2 = Somewhat Unlikely, 3 = No effect on likelihood, 4 = Somewhat likely, and 5 = Very likely. The median score (see Table 1) suggested that students were somewhat likely to view captured lectures in both tightly and loosely coordinated courses. A Wilcoxon signed-rank test showed curricular coordination level did not significantly influence students' likelihood of watching captured lectures ($Z = -1.798$, $p = .072$).

2.2.3. Content type and student use of captured lectures

Students were equally likely to review captured lectures from courses regardless of whether the courses had a clinical/problem solving, basic science – applied, or basic science – research orientation ($Z < 1.9$, $p > .070$, in all cases). They reported being significantly less likely to review captured lectures of non-traditional courses than any of the other three course types: Problem Solving ($Z = -9.540$, $p < .0005$), Basic Science – Applied ($Z = -10.242$, $p < .0005$), or Basic Science – Research Orientation ($Z = -9.951$, $p < .0005$).

2.2.4. Other factors affecting students' self-reported likelihood of using captured lectures

Table 1 provides a summary of all factors that students identified as influencing the likelihood that they would watch a captured lecture. The most common reasons for watching a captured lecture appeared to be pragmatic ones – to review specifically flagged portions of lectures, to try to keep up with fast-moving lectures, to study for exams, and to review missed material. Students were less likely to indicate that captured lectures were used to review for classes missed deliberately, to verify the consistency of material presented among instructors, or to review how concepts taught at the end of one class period related to concepts taught at the beginning of the next class period. Similarly,

instructor characteristics influencing students' decisions to review or not to review captured lectures were generally pragmatic. Students were very likely to review lectures that were delivered very quickly or in cases where the instructor had not made material available in any other way, and the students considered the material to be relevant. Not surprisingly, students reported being less likely to review captured lectures when they considered the material to be irrelevant, or to provide little in addition to other material (e.g., when the lecturer reads the slides to the students). The quality of instruction (perceived quality of the lecturer, or organization of the material) was not an important factor in whether or not students would choose to watch captured lectures.

2.2.5. Faculty perception of the value of lecture capture by teaching approach, curricular coordination and content type

Instructor responses to the question "In general, do you believe students are more likely to learn better with lecture-capture technology?" were explored by instructor teaching approach, course type, and curricular coordination. In no case were the differences statistically significant, as indicated by a Kruskal–Wallis test (teaching approach: Chi-Square = 3.057; df = 3; Asymp. Sig. = .383; course type: Chi-Square = 1.221; df = 3; Asymp. Sig = .748; curricular coordination: Chi-Square = 1.633; df = 2; Asymp Sig = .442). This suggests that neither instructors' teaching approach nor the kind of content they were teaching were meaningfully associated with their perception of lecture-capture technology and use.

2.2.6. Perceived effect of lecture capture on learning

Students overwhelmingly indicated that lecture capture helped them to learn better. In response to the item, "In general, are you more likely to learn better with lecture-capture technology?", 93% of students indicated that they were very or somewhat likely to learn better with lecture capture, 5.4% felt that lecture capture would not affect the likelihood that they would learn better, and only 0.5% thought it unlikely that they would learn better with lecture capture. Faculty were more conservative in estimating the effect of lecture capture on learning, with 36.4% indicating that lecture capture would be somewhat or very likely to help students learn better, 45.5% indicating that lecture-capture use would be unlikely to affect learning, and 18.2% indicating that lecture capture would be somewhat or very unlikely to help students learn better.

Results to open-ended comments helped to shed additional light on Likert-item responses from both faculty and students. Table 2 contains a summary of faculty members' general perceptions of lecture capture as reflected in open-ended comments. Faculty who perceived a disadvantage to lecture capture generally placed importance on the classroom dynamic, which they felt was interrupted by lecture capture, frequently by way of absenteeism. For instance, one instructor commented, "The classroom dynamics are altered when student numbers drop below a certain point. The behavior of the INSTRUCTOR changes (based on personal experience and comments from other faculty members) when students choose to not be in the classroom. The absence of students probably has a significant effect on faculty performance…which hopefully is important in providing quality instruction." Another stated, "… it [lecture capture] dramatically changes the classroom dynamics if a significant (?) percentage of students are absent from discussions/question&answer sessions, etc." Another said, "If attendance is part of the grade for the class then have the students do something during the class period that earns them points that they

Table 2
Faculty responses to open-ended questions (responses only reported when from at least 10% of respondents e.g. $N = 4$).

Answer	*N*
Question 1: what advantages does lecture capture provide you as an instructor?	
No advantages perceived	10
Students can review the lectures	7
I (faculty) can review my own performance	4
Question 2: what advantages does lecture capture provide students in your class?	
Students can review information after class	15
Students can view material they missed if absent	10
Question 4: what are the drawbacks to lecture capture for you as an instructor? *and* *Question 6: what do you like least about the lecture-capture program at ISU?*	
Lower class attendance	7
Students are less attentive or less likely to ask questions	5
Forced formality or less autonomy	5
Question 5: what are the drawbacks of lecture capture for students in your class?	
It encourages students to be absent	4
May inhibit student interaction in class	4
May cause students to over rely on the captured lecture and not pay attention in class	4
Question 7: do you notice a change in attendance when lecture captures are available? If so, please explain how attendance is affected.	
No change	10
Yes (reduced generally, or at specific times, such as late in the semester or before exams)	10
Question 10: some instructors are concerned that if students started using captured lectures as an alternative to attending class, it would be detrimental to their learning. How would you respond to that?	
Agree	11
Disagree	9
Reduces participation/interaction	4

cannot make up if they are not in class; regardless of the captured lectures. Some students may learn better reviewing captured lectures but there is still merit to attending class, in my opinion."

Faculty who perceived an advantage to lecture capture emphasized the convenience to both student and instructor of having lectures available after the fact. Faculty comments in this category reflected less concern with student absenteeism, either because the instructor didn't believe absenteeism would affect learning, hadn't noticed a change in attendance, or seemed to feel responsible for providing some reason for students to attend class other than or in addition to receiving course content. For instance, one instructor noted, "Students are going to attend or not even without Echo. Give them something that they want to be there for and they will!" Another said, "Students tell me that they use the captures if they cannot be in class because of a meeting or doctor's appointment etc. They do not use the captures to skip class. The exception is if a professor simply reads the notes in class. Then they can listen to the capture and at least get the dishes done at the same time." Another said, "It's their life – if they can learn this way why do I care if they are in the classroom or not??"

3. Second study – lecture capture and learning

Researchers have tended to utilize one of two common approaches to estimate the impact of lecture capture on learning. The first approach investigates whether or not choosing to use lecture-capture impacts learning for the individual student. In this approach, students within a group can choose whether they will use captured lectures or not, and the scores of those choosing to review captured lectures are compared with the scores of those choosing not to use captured lectures (von Konsky et al., 2009; McNulty et al., 2009, 2011). In the second approach, a particular teaching approach is used with an entire group, and outcomes are compared between groups (Dey et al., 2009; Elsasser et al., 2009). We used the second approach because our lecture-capture use data were available by group and not by individual, and because we wanted to know how lecture-capture use affected learning at the group level. This is an important question in light of the concern expressed by some faculty members from the first study that lecture-capture use might affect attendance and/or interactivity, which might in turn affect learning for all students, not just for those who did or did not use captured lectures. We characterized existing student cohorts based on their accessibility to captured lectures and their average lecture-capture view rate. Using the categories identified in the prior study, we categorized lecture captures according to content area and predominant teaching approach. Because level of curricular coordination was not consistent among courses within a given content area, we did not consider curricular coordination in this study. Finally, we compared student performance across groups using a standardized measure of learning in the basic sciences.

3.1. Method

3.1.1. Participants

The participants included all veterinary students in the graduating classes of 2008–2011 ($n = 491$) who were enrolled in the same mid-western veterinary college that was involved in the first study. These participants, therefore, had the same general characteristics as the students described in the first study.

3.1.2. Instruments

The Qualifying Exam of the National Board of Veterinary Medical Examiners was used to measure student learning. The Qualifying Exam is a commercially available standardized test of basic science knowledge and skills which is used as part of the licensure process for students who graduate from veterinary colleges that are not accredited by the Council on Education of the American Veterinary Medical Association. All students enrolled at the veterinary school where the study was conducted were required to take the Qualifying Exam during January of their third year for purposes of formative evaluation. All students received an overall score on the exam, as well as a score for each of five sub-areas (Anatomy, Microbiology, Pathology, Pharmacology, and Physiology.)

3.1.3. Procedure

This study was approved by the Institutional Review Board (IRB) of the university where it was conducted. As described in Section 3.1, lecture-capture availability gradually increased as the shift from an opt-in to an opt-out approach led to increased adoption of the Echo360 technology.

To relate lecture-capture viewing frequency with student performance on the Qualifying Exam, we used the Echo360 logs to count how often captured lectures were accessed for all courses which could have helped prepare students in the graduating classes of 2010 through 2012 for the Qualifying Exam. All students took the Qualifying Exam at the beginning of their sixth semester of instruction. Thus, we included only lecture captures from courses occurring prior to the sixth semester of the curriculum. We categorized these courses according to their fit within the five basic science areas measured by the Qualifying Exam: Anatomy, Microbiology, Pathology, Pharmacology, and Physiology. Additionally, all broad course categories were categorized by content type and predominant teaching approach as seen in Table 3. Courses covering content that was not explicitly measured by the Qualifying Exam (such as Medicine and Surgery) were excluded from the analysis.

Table 3
Course categories by content type and teaching approach.

Course group	Content type	Teaching approach
Anatomy	Basic science – research orientation	Predominantly lecture with laboratory
Microbiology	Mixed	Predominantly lecture with laboratory
Pathology	Basic science – applied orientation	Mixed lecture/group work with laboratory
Pharmacology	Basic science – research orientation	Predominantly lecture
Physiology	Basic science – applied orientation	Predominantly lecture with some mixed lecture/group work

Table 4
Lecture-capture use level (views per student per week).

Class	Anatomy	Microbiology	Pathology	Pharmacology	Physiology	Overall
2008	–	–	–	–	–	–
2009	–	–	–	–	–	–
2010	–	–	–	0.4 (Low)	0.1 (Low)	0.5 (Low)
2011	–	2.6 (Medium)	0.5 (Low)	1.9 (Medium)	0.3 (Low)	5.2 (High)
2012	0.47 (Low)	3.1 (High)	0.6 (Low)	1.6 (Medium)	0.3 (Low)	6.1 (High)

Note: – means that no lectures were viewed, either because they were not available or the instructor did not allow viewing.

We determined the lecture-capture access frequency for each graduating class and calculated the average lecture-capture views per student per week within all courses in each broad content area corresponding with each Qualifying Exam sub-score. For example, in courses offering Microbiology-related content, a typical student in the graduating class of 2011 viewed 2.6 captured lectures per week (see Table 4). Note that this figure provides a broad sense of how many captured lectures were accessed, but technical limitations prevented us from tracking the quantity of lectures viewed by individual students, whether students viewed a full lecture or only part of a lecture, and what portion of the lecture was viewed.

We classified average viewing frequency as low, medium, or high, based on how many lectures students reported viewing during "light", "average" and "heavy" lecture-capture usage weeks. According to average student survey responses from the first study, students reported accessing 1.1 lectures during a light use week, 2.4 lectures during an average use week, and 5.3 lectures during a heavy use week. Based on these categorizations, we characterized each graduating class's utilization of lecture capture in each content area as "none" (0 lectures accessed per week), "low" (.01–1.3 views per week), "medium" (1.4–2.9 views per week) views per week, or high (>2.9 views per week) (see Table 4). In cases in which 0 lectures were accessed per week, either lecture capture was not yet available (this was always true for the classes of 2008 and 2009) or instructors were not yet making lectures available to students in specific areas. For instance, although lectures were being captured in Anatomy courses in 2008, the instructor policy did not allow students to access captured lectures until 2009, when students in the graduating class of 2012 began to take anatomy courses.

An Analysis of Covariance was conducted on overall learning as measured by the Qualifying Exam. Level of lecture-capture use was used as the independent variable. In order to control for other curricular changes, inherent differences between cohorts, or similar factors that could affect outcomes, academic class was used as a covariate. An Analysis of Covariance was also conducted on performance for each Qualifying Exam sub-section, with level of lecture-capture use within each sub-section used as the independent variable and academic class used as a covariate. All analyses were conducted using IBM SPSS version 19.

3.2. Results

3.2.1. Lecture-capture use

Table 4 shows lecture-capture use level overall and by sub-discipline for the graduating classes of 2008–2012. Overall, there were no views by the graduating classes of 2008–2009 (lecture captures were not available), low views by the class of 2010, and high views by the classes of 2011 and 2012. Average viewing frequency varied by discipline area, and there were discernible patterns in these variations. Viewing frequency for Physiology and Pathology were similar. Overall, each student accessed one captured lecture every two to three weeks in these disciplines. Views for Pharmacology and Microbiology courses were also similar to each other. Beginning in 2011, students viewed a "medium" number of lectures (1.6–1.9 per week) in Pharmacology courses, and a medium to high number of lectures (2.6–3.1 per week) in Microbiology courses. Views of captured lectures in Anatomy did not begin until 2012, and were low (0.47 views per week, on average.) However, it should be noted that Anatomy instructors constrained the number of views by making lectures unavailable 2 weeks after the date that lectures were given; in an unconstrained setting, views would likely have been higher.

3.2.2. Lecture capture and learning

Table 5 presents the results of the ANCOVA for the QE overall, and for each sub-score. As seen, the covariate *Class* (referring to the graduating class, or cohort), as well as the Independent Variable, *Echo Views* had significant effects for the subscales of Anatomy, Microbiology, and Pharmacology, but not for the other subscales or for the overall test score. Table 6 presents the estimated marginal means for each comparison, and the specific differences that were significant. For the anatomy subscale, students in classes that viewed a low number of recorded lectures scored higher than students in classes that viewed no recorded lectures. For the Pharmacology subscale, students in classes that viewed a medium number of recorded lectures scored higher than students in classes that viewed a low number of recorded lectures, or no recorded lectures, and students in classes that viewed a low number of recorded lectures scored higher than students in classes that viewed no recorded lectures. For the Microbiology subscale, students in classes that viewed no recorded lectures scored higher than students in classes that viewed a medium amount of recorded lectures, but scored equivalently to students in classes that viewed a high number of recorded lectures. Differences due to *Class* (cohort) contributed more to differences in Microbiology scores than differences due to *Echo Views*.

4. Discussion

4.1. Perceptions and use of lecture capture

The negative relationship between the level of interactivity and the likelihood that students would view captured lectures could be explained by the fact that lecture-capture technology, as implemented for this study, primarily captures what the instructor does; other interactions are lost. Some student comments also suggested that content delivered by the instructor can be instructionally beneficial when

Table 5
ANCOVA summary table.

Source	df	F	η^2
Qualifying exam overall			
Class	1	0.39	0.001
Echo views	2	0.002	0.000
Error	610	(1968.65)	
Anatomy			
Class	1	11.476***	0.018
Echo views	1	62.240***	0.092
Error	611	(86.790)	
Microbiology			
Class	1	12.474***	0.020
Echo views	2	5.676**	0.018
Error	610	(96.291)	
Pathology			
Class	1	0.873	0.001
Echo views	1	0.852	0.001
Error	611	(87.916)	
Pharmacology			
Class	1	8.995***	0.015
Echo views	2	16.350***	0.051
Error	610	(145.443)	
Physiology			
Class	1	1.088	0.002
Echo views	1	0.820	0.001
Error	611	(110.099)	

Note. Values enclosed in parentheses represent mean square errors.
*$p < .05$, **$p < .01$, ***$p < .005$.

reviewed, whereas, "you have to be there" to benefit from activities such as clicker questions and group learning activities. We found no evidence in the survey responses to suggest that curricular coordination or course content type are important factors to veterinary students when deciding whether or not to view a captured lecture, other than in the case of non-traditional courses. Note that student perceptions of curricular coordination may not accurately reflect whether or not instructors attempted to coordinate their efforts while designing and implementing the class. Nonetheless, students have the most accurate perception of how well coordinated a course actually seems in practice.

There is very little to be said about the relationship between any of our independent variables and faculty attitudes toward lecture capture, other than to observe that there was no relationship detected. There were relatively few faculty in each group, which may have hindered our ability to detect statistically significant differences. Nonetheless, a casual glance at median scores shows that faculty were generally ambivalent regarding the likelihood that lecture capture will help learning, regardless of teaching style, course type, or the level of curricular coordination in the courses they teach. The small number of faculty in each group is certainly a weakness of the study; there is some chance that we committed a type 2 error. Given the small numbers of instructors in veterinary colleges, it seems unlikely that this problem could be addressed without involving other colleges in the study. If the present study were considered a pilot study for a more expansive study, it fails to make a case that these particular independent variables would be important for predicting faculty members' overall perception of the usefulness of lecture capture.

Students chose to view a relatively low number of captured lectures in two of the discipline areas: Physiology and Pathology. As seen in Table 6, these two areas have several things in common. Both are categorized as "Basic Science – Applied Orientation", and both employ some Mixed Lecture/Group work. Similarly, students reviewed a relatively higher number of lectures for at least two discipline areas that rely more heavily on lecture: Microbiology and Pharmacology. This result supports the students' self-report from the first study that they are less likely to view captured lectures for courses that have more interactivity than for courses that have more lecture. The observation that students reviewed a relatively low number of lectures in Anatomy appears to contradict this rule; however, because the number of Anatomy views was constrained by the faculty, it is not safe to conclude that this low level of views was by student choice.

Table 6
Estimated marginal means (standard error) by views.

Measure	No views	Low views	Medium views	High views	Difference
Qualifying exam overall	230.9 (7.1)	230.5(4.3)	–	230.5 (5.9)	No significant differences
Anatomy	53.0 (0.5)	63.0 (1.0)	–	–	Low views > no views***
Microbiology	64.3 (1.0)	–	59.4 (1.0)	61.1 (1.5)	No views > medium views**
Pathology	65.8(0.8)	64.3(0.9)	–	–	No significant differences
Pharmacology	46.4(1.9)	52.0(1.2)	63.8(2.0)	–	Medium views > low views, no views***; low views > no views*
Physiology	57.4 (1.2)	59.0(0.8)	–	–	No significant differences

Note. *$p < .05$, **$p < .01$, ***$p < .001$ using a Bonferroni confidence interval adjustment.
"–" Indicates that the views category was not applicable for that measure.

4.2. Lecture capture and learning

Students perceived that lecture-capture use helped their learning, particularly in lecture-oriented courses; the scores for Pharmacology and Anatomy support this perception. The fact that captured lecture views were not related to scores on the Pathology and Physiology sub-scores also seems consistent with the students' perception that captured lectures are less helpful in more interactive courses than in less interactive courses. The results for the Microbiology sub-section suggest that, for this content area, some other factor had a greater effect on QE scores than did use of captured lectures; the class covariate contributed more to differences than did lecture views.

Research and theory in the field of Instructional Technology and related fields provide no strong reason to expect that simply providing students with captured lectures would improve learning. Interventions that provide students with meaningful practice and feedback, opportunities to retrieve previously learned information, and that meaningfully contextualize new information in the context of prior information all seem more likely to affect learning than simply making pre-recorded lectures available (Bransford, Brown, & Cocking, 2000; Ericsson, 2004; Hattie & Timperley, 2007; Karpicke & Blunt, 2011; Merrill, 2002). However, the present study, for at least some conditions, supports the idea that access to lecture capture can improve student learning outcomes, and certainly that captured lectures can be made available without endangering learning outcomes. There are several reasons that the availability of captured lectures might have been beneficial for learners in the present study.

Several authors have pointed to Mayer's Cognitive Theory of Multimedia Learning (Mayer, 2005) as a useful framework for explaining learning in the context of lecture capture (Dey et al., 2009; Owston et al., 2011; Scutter et al., 2010). From this perspective, students are able to simultaneously process any information presented through visual and auditory modalities simultaneously (the dual channel assumption), and benefit from instruction that respects the processing limitations of human cognition (the limited capacity assumption) and supports learners in creating coherent representations of their experiences (the active processing assumption). As a result, multimedia instruction "should be designed to prime these processes." (Mayer, 2005, p. 31). Certainly if lecture capture is well-suited to human cognition, it would be as likely to help veterinary students as any other students. Nonetheless, the extent to which a captured lecture is helpful, under the Cognitive Theory of Multimedia Learning framework, is likely to have much to do with the way the specific lecture was designed, and less to do with whether or not a learner viewed it live and in person or as a recording. Therefore, this explanation seems inadequate for explaining any benefit found in the present study.

Another potential explanation comes from a recent second-order meta-analysis involving 25 meta-analyses and encompassing 1055 primary studies. That study found a mean effect size of 0.33 favoring learning outcomes in environments where computer technology was used in the context of formal face-to-face classrooms as compared to classrooms that did not use technology (Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011). Such a finding, involving studies that were conducted in many settings and involved a number of theoretical perspectives, supports the idea that when people set out to design and use new technologies in the pursuit of learning, they find ways to improve things. Such findings could, of course, also show that authors and journal editors prefer to publish positive findings (e.g. the file drawer effect). However in the context of this particular question, negative findings are just as desirable to many stakeholders as positive findings, reducing somewhat the likelihood of a file drawer effect for this particular question.

Another perspective on the potential benefit derived from captured lecture has more to do with the flexibility that the format provides to students, and less with the particular nature of the technology itself. In several studies, students have reported that lecture capture provided added flexibility (Brotherton & Abowd, 2004; Cardall et al., 2008; Franklin et al., 2011; Spickard et al., 2002). For instance, pharmacology students reported that recorded lectures provided more flexibility in study habits and self-directed learning (Franklin et al., 2011), and students participating in a lecture-capture-style online section of an out-patient clerkship demonstrated equal learning to students in a live lecture group, and did so in significantly less time (Spickard et al., 2002). The ability to experience equivalent learning gains in less time would be particularly valuable for veterinary students. Multiple studies have shown that veterinary students experience high levels of anxiety and depression when compared with otherwise similar groups (Hafen, Reisbig, White, & Rush, 2006; Reisbig et al., 2012; Siqueira Drake, Hafen, Rush, & Reisbig, 2012), and that the anxiety and depression are strongly predicted by academic stressors, including academic workload (Reisbig et al., 2012). This would not be hard to explain in the context of veterinary medical education; because veterinary students are required to learn typical medical knowledge and skills (e.g. anatomy, physiology, pathology, surgery, medicine, etc.) across a number of species, they must master a great deal of information in a short period of time. It seems reasonable that any technology that allows students to save time while learning equivalently in any area would produce less stress and more time for studying or resting, and therefore, improved learning outcomes. We find this to be the most compelling explanation for any benefit that might be revealed by the present study.

Regardless of other theoretical considerations, there are several potential implications for considering when and how to implement lecture capture in light of the present study. First, although in the first study a number of faculty expressed concern that the use of lecture capture would reduce student learning outcomes – primarily by hampering the face-to-face educational experience – the present study provides no evidence to support this concern. In no case were decreased learning outcomes associated with the implementation of lecture capture. Second, it appears that students, at least in this context, were reasonably good judges of when lecture-capture use would be beneficial. With the exception of Microbiology, in which factors that were unrelated to lecture capture played a greater role than factors related to lecture capture, the use of lecture capture was associated with learning gains in the types of classes in which students believed it would. In contrast, in the sorts of classes in which students believed lecture capture would be less beneficial, they used it less, and there was no evidence to suggest any benefit. Specifically, captured lectures were generally more frequently accessed, and more helpful, in classes that relied on less interactivity than in those that were more interactive.

4.3. Limitations

There are a number of limitations to the present studies. First, in the first study we chose to collect the surveys anonymously in order to reduce the likelihood of response bias. As a result, we were unable to characterize non-responders for the purpose of identifying systematic differences between responders and non-responders. Therefore, it is possible that selection bias influenced the results of the first study. For instance, students and/or faculty who were strongly in favor of or opposed to lecture capture might have responded in greater numbers than

those who were more ambivalent. Because the veterinary education environment demands a great deal of time from both faculty and students, it is also possible that non-respondents were just exceptionally busy at the time of the survey.

Second, the present studies were conducted in a veterinary medical education environment in the United States, which is characterized by mature, disciplined, and highly motivated learners studying scientific and/or technical content. Similarly, many of the learners in the present studies came from similar educational backgrounds and shared similar assumptions about the importance of various learning approaches. Furthermore, while our results seemed consistent with a number of the articles we cited, those studies, like ours, were predominantly conducted in scientific, technical, and/or medical post-secondary contexts, and all were conducted in the United States, Great Britain, Canada, or Australia. Therefore, the results of the present study might not generalize to other disciplines, younger or less motivated learners, or cultures that place more or less value on lecture as the preferred way of learning.

Finally, while the present studies provide insight into faculty and student perceptions of lecture-capture effectiveness, as well as learning outcomes associated with lecture-capture use, we did not discuss cost/benefit considerations. Analyzing relative costs and benefits including infrastructure, licensing fees, instructor and student time, educational material distribution, and so forth, is an endeavor worthy of in-depth attention and is beyond the scope of the present study.

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